Food safety management and risk assessment in the fresh produce supply chain

IOP Conf. Series: Materials Science and Engineering **193** (2017) 012020 doi:10.1088/1757-899X/193/1/012020

Food safety management and risk assessment in the fresh produce supply chain

L Jacxsens[1], M Uyttendaele[1], P Luning[2], A Allende[3]
[1] Laboratory of Food Microbiology and Food Preservation, Department of Food Safety and Food Quality, Ghent University
[2] Product Design and Quality Management Group, Department of Agrotechnology and Food Sciences, Wageningen University, P.O. Box 8129, NL-6700 EV Wageningen, The Netherlands.
[3] Research Group on Quality, Safety and Bioactivity of Plant Foods, Department of Food Science and Technology, CEBAS-CSIC, P. O. box 164, Espinardo, Murcia, E-30100, Spain

E-mail: liesbeth.jacxsens@ugent.be

Abstract. This paper is the output of several years of scientific research coordinated by Laboratory of Food Preservation and Food Microbiology at UGent, within the EU FP7 Research project Veg-i-trade (www.vegitrade.org), in collaboration with among other partners, Wageningen University and Cebas-CSIC. Fresh produce and derived products are globally traded and subjected to an inherent sensitive towards enteric pathogens as Salmonella and pathogenic E. coli due to their cultivation practices. As fruits and vegetables are increasingly being consumed raw, a potential health risk towards consumers is present. In the Veg-i-Trade project the extend of presence of pathogens in leafy greens and strawberry fruit and their cultivation environment (as water, soil, manured soil, etc.) was analysed. Insight in the food safety management system enlighted the need for further fostering and guidance towards farmers in good practices in order to reduce the potential pressure of the presence of the pathogens both in EU and non EU countries. Exposure assessment calculations demonstrated the usefulness of mathematic modelling to gain more insight in fragmented microbiological analysis and information of cultivation practices, as such the impact of contamination of irrigation water and the impact of a flooding event. Veg-i-Trade was a challenging project both in scientific and management perspective as 23 partners collaborated.

1. Introduction

Fruits and vegetables are increasingly being consumed and also raw consumption became important [1]. The current quality assurance and control tools and methods to prevent and/or to control microbiological risks associated with fresh produce are challenged due to the following pressures upon the food supply chain, i.e. changing consumption patterns, globalization and climate change. It demonstrates the need for scientific research and development of new and/or improved tools, techniques and practices to adapt the current risk management systems. A conceptual research approach is presented to analyse the complexity of the climate change and globalization challenge on the fresh produce supply chain taken as a case study. The factors which affect the vulnerability of the fresh produce chain demand a multidisciplinary research approach. The proposed knowledge-based modelling system is believed to be a most appropriate way to identify problems and to offer solutions

to monitor and prevent microbiological food safety risks during all phases of food production and supply. To explore the potential impact of climate change and globalization, baseline information can be obtained by surveillance and performance measurement of implemented food safety management systems. Simulation of climate change scenarios and the logistic chain of fresh produce, along with mathematical models to optimize packaging technology to maintain quality and safety of fresh produce are tools to provide insights in the complex dynamic ecosystem. They are the basis for elaboration of risk assessment studies to scientifically support management options and decisions to new microbiological threats related to globalization and climate change in the fresh produce supply chain. This research concept as such will contribute to develop strategies in order to guarantee the (microbiological) food safety of fresh produce on the long term [2].

2. Fresh produce and derived food products and microbiological safety

Fresh produce and derived food products are food from non-animal origin and are more and more linked with biological food safety issues, such as presence of parasites, pathogenic bacteria as *Salmonella* or pathogenic *E. coli* and foodborne viruses as Norovirus. In particular, as on a world level still quantities of fresh fruit and vegetables traded represent a limited part of what is produced, the concept of safe food for all is a key issue. The main objective of the present study is to investigate whether and which factors could be identified as universal risk factors for pathogen contamination of fresh produce across farms in various countries with variable climate and agro-technical management practices. For this purpose leafy greens, strawberries and their primary production environment (soil, water, contact surfaces) were analyzed for the presence of *Salmonella*, STEC, *Campylobacter* and the amount of generic *E. coli* using a similar sampling plan at a variety of farms in Belgium, Brazil, Egypt, Norway and Spain within the framework of the European Veg-i-Trade project, executing research on the topic of microbiological (and chemical) safety of fresh produce in a global context.Water samples were more prone to containing pathogens (54 positives out of 950 analyses) than soil (16/1186) and produce on the field (18/977 for leafy greens and 5/402 for strawberries). The prevalence of pathogens also varied markedly according to the sampling region. Flooding of fields increased the risk considerably, with odds ratio (OR) 10.9 for *Salmonella* and 7.0 for STEC. A significant association between elevated numbers of generic *E. coli* and detection of pathogens (OR of 2.3 for STEC and 2.7 for *Salmonella*) was established. Generic *E. coli* was found to be a suitable index organism for *Salmonella* and STEC, but to a lesser extent for *Campylobacter*. Guidelines on frequency of sampling and threshold values for *E. coli* in irrigation water may differ from region to region [3].

3. Food safety management systems (FSMS)

The fresh produce chains are nowadays increasingly challenged to also respond to demands on environmental and social accountability. It is clear that climate and climate change should not be ignored as a factor, and will in particularly affect the introduction of contaminants at the pre-harvest stage. Fresh produce supply chains natural evolved to obtain effective food safety management which is also embedded in the striving to bring sufficient and nutritious good quality fresh produce to the consumer. Three self-assessment tools were developed which were shown useful as an internal audit system to track the current status of “best practices” or maturity of the “management systems” implemented at primary production, processing or trade. They consist of 64 to 69 indicators and address core control and assurance activities in the prevention and reduction of microbiological, mycotoxin and pesticide residue contamination. Each indicator uses grids with supporting information for self-assigning to situation 1 (basic level), 2 (average level) or 3 (advanced level). Selected indicators and grids as such provide a ‘bird’s eye view’ of the performance level of the current systems in place, the risk level of the context wherein the actor has to operate, and an indication of the system’s output. Primary production companies (n = 118), located in the EU and in international cooperation partner countries exporting to the EU, were assessed by using a diagnostic tool. The results from the study indicated that several factors have a dominating effect on the status of FSMSs in the global fresh produce chain. International export supply chains promote capacity building within

companies in the chain, to answer the stringent requirements of private brand standards. This was shown to be an important factor in emerging and developing countries, where local institutional environments often fail to support companies in setting and implementing their FSMSs. Moreover, the legislative framework in these countries still requires improvements in the establishment and enforcement. All this has negative consequences for the FSMSs in companies supplying the local markets. In companies located in the EU, sector and other produce organisations facilitate the sampling for pesticide residues and collaboration in the sector. Overall, farmers showed less knowledge and overall awareness regarding microbiological hazards, which is related to the less attention paid to these in the current legislation and standards. Furthermore, standards are an important tool to trigger the maturation of the systems as companies that were lacking any pressure to comply to standards operated at a very basic level - with only few activities implemented. The insights from this study indicate the need of stratified measures and policies to support companies in the fresh produce chain in designing and operating their FSMSs according to the institutional environment in which they operate [4].

4. Exposure and Risk assessment

A quantitative exposure model for generic ***E. coli*** was developed to estimate the occurrence and levels of ***E. coli*** under defined circumstances of agricultural production of leafy greens. It was noted that apart from the regional variable baseline distribution of ***E. coli*** numbers in the irrigation water or the soil, the cultivation season and interlinked with this the length of the crop cycle, rainfall and extent of solar radiation influences the ***E. coli*** levels substantially in case of open field production. (based on Castro Ibanez et al., submitted for publication). A probabilistic quantitative exposure assessment model was developed to compare the distribution of contaminated portions of basil, strawberry and butterhead lettuce to which Belgian and Spanish consumers are exposed per year. The highest number of contaminated portions was found for basil compared to butterhead lettuce and strawberries which can be explained by the observed higher prevalence of enteric pathogens, their better survival during storage and less consumers washing the basil before consumption. A daily consumption of basil leads to exposure of five to nine contaminated portions a year, both in the Belgian and Spanish situation. The lowest exposure to the pathogens was observed for strawberries in the Spanish situation due to lower consumption frequency in combination with higher die-off of the enteric pathogens on strawberries. Scenario analysis revealed that the main driving force in exposure is prevalence of pathogens, a moderate effect of consumption frequency and to a minor extent consumer behavior. This quantitative exposure ranking demonstrates that also niche products such as basil can have an potential impact on public health equal or higher than lettuce, resulting in a priority in monitoring and surveillance (based on Jacxsens et al., submitted for publication).

Finally, a gap analysis was conducted via a systematic review of current published information on the impact of contaminated water towards the potential risk of pathogens on fresh produce. Both papers from water science groups and food research groups are included [5]. Risk assessment related to use of water and safety of fresh produce orient from both water and food microbiology studies. Although the set-up and methodology of risk assessment in these two disciplines may differ, analysis of the current literature reveals some common outcomes. Most of these studies from water perspective focus on enteric virus risks, largely because of their anticipated high concentrations in untreated wastewater and their recalcitrance to common wastewater treatments. Risk assessment studies from the food perspective rather focus on bacterial pathogens such as Salmonella and pathogenic E. coli. Few sitespecific data points were available for most of these microbial risk assessments, meaning that many assumptions were necessary which are retaken in many studies. Specific parameters lacking hard data included rates of pathogen transfer from irrigation water to crops, pathogen penetration, and survival in or on food crops. Data on these factors have been investigated over the last decade and this should improve the reliability of future microbial risk estimates. However, the sheer number of different foodstuffs and pathogens, combined with water sources and irrigation practices, means that developing risk models that can span the breadth of fresh produce safety will be a considerable challenge. The new

approach using microbial risk assessment is objective and evidence-based and leads to more flexibility and enables more tailored risk management practices and guidelines. Drawbacks are however capacity and knowledge to perform the microbial risk assessment and the need for data and preferably data of the specific region [5].

5. References

[1] Jacxsens L, Castro Ibanez I, Gomez-Lopez V, Fernandes J, Allende A, Uyttendaele M, I Huybrechts 2015 *J. Food Prot.* **78** 784-95.
[2] Jacxsens L, Luning P, Van de Vorst J, Devlieghere F, Leemans R, Uyttendaele M 2010 *Food Res. Int.* **43** 1925-35
[3] Ceuppens S, Johannessen GS, Allende A, Tondo EC, El-Tahan F, Sampers I, Jacxsens L, Uyttendaele M 2015 *J. Environ. Res. Public Health* **12** 9809-31.
[4] Kirezieva K, Luning P, Jacxsens L, Allende A, Johannessen G, Tondo E, Rajkovic A, Uyttendaele M, van Boekel M, 2015 *Food Control* **52**, 85-97.
[5] De Keuckelaere A, Jacxsens L, Amoah Ph, Medema GJ, McClure P, Jaykus LA, Uyttendaele M 2015 *Compr. Rev. Food Sci. Food Saf.* **14**, 387-410